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A NOVEL PRODUCT DEVELOPMENT APPROACH FOR COST AND TIME SAVING BY ADOPTING CELLULAR PROTOTYPE MANUFACTURING CONCEPT

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ABSTRACT

In the present times the challenge is to utilize manufacturing line more productively to achieve faster launching of new products in the market. Prototype manufacturing is the key to achieve the product launches in minimum development time. As manufacturing lines have capacity constraints, a new evolved prototype manufacturing for bearing development has become possible to obtain bearing in time to market. On prototype manufacturing setup variable tooling's are less in quantity as compared to bearing manufacturing online setup. As a result tooling design and development time are less and cost-effective. Prototype manufacturing has proven that effective utilization of machines supports bearing industry to minimize manufacturing time and also majorly reduces the overall product development time. The paper discusses the prototype manufacturing of bearing in Protoshop. The paper also presents time and cost saving in the manufacturing of the new product in Protoshop. There is significant reduction observed in cost by 81% and time by 60% with the help of prototype manufacturing. It is evident from the current study that adoption of prototype manufacturing within an organization not only productivity helps in having smooth, regular production by overcoming major issues related to more setting on manufacturing lines and capacity.

KEYWORDS: Prototype Manufacturing, New Product Development (NPD), Time Reduction, Cost reduction & Bearing

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Original Article

INTRODUCTION

In today's market, new product development (NPD) is required by customers in much shorter times as compared to succeeding years; thisis caused due to their need of launching of new models in the competitive market. This necessitates the need for faster development cycles as well. To provide products as per demanding market requirement product development cycle time to reduce by developing products offline or by prototype development, from industry perspectives these two solutions have been working well since last few years. Due to change in global competition, different technology and customer expectation firms face an uncertain environment (Sethi, A.K., &Sethi, S.P., 1990;Sethi, R. et al, 2003). To respond to every changing and demanding market requirements, customers are demanding for faster new product development from complete manufacturing chain. New product manufacturing typically starts with complete line tooling design and development, line loading, line setting, product manufacturing on production lines. In case of manufacturing of bearings, the number

of tools involved is pretty high. With an approximate estimate of more than 200 individual components, developing sample bearings activity time and the cost is increasing. Due to excessive market demand and pressure of regular products the manufacturing resources are constrained between, existing versus futuristic demands. The futuristic demands since is only a probability of future income is treated secondary in front of the existing demand. This poses a risk of delaying customer orders and annoying the customer.

Prototype manufacturing setup is the proven way towards the development of products in automotive industries, which helps in developing samples as per customer satisfaction. Sample development time is reduced due to design and development efforts required for prototype manufacturing are less complex than that required for mass production. Currently prototyping has created more interest in the product development research groups. In early stage, prototyping has become the main action with the growing attention in acquiring Design Thinking (DT) in different business and product development area. Opposite to the Prototyping commonly is given in conventional engineering design opposite to the proof-of-product' character (Ullman, 2010). The prototyping method requires selecting the correct plan for prototyping, whether it is physical or digital. Ulrich & Eppinger, give very important details in case of new product development, for product developers by outlining the main concept of prototyping and in a product development project, suggest how prototypes should be schemed(Ulrich & Eppinger, 2012). These recommendations could be an important for beginning point of product development professional who desires to acquire knowledge further about prototyping, utilize prototyping in the development procedure as a tool. Though, examining the range and variety of the research on prototyping, this appears to be required for synthesized outcomes that accumulate research from the different research area and gives instinct for product developers. It is difficult to recognize most important contextual elements to make sound decisions. This includes a lesser number of specialized equipment and specialized jigs and fixtures required for a specific job. Overall prototype setup for bearing sample development reduces the product development lead time. However, it has been observed that in-spite of prototype platform implementation in organizations; the effective utilization of prototype manufacturing setup is intermittent.

This paper addresses a key issue of sample development time required during new product development activity. The established cellular manufacturing setup contains mostly generic manufacturing resources to avoid frequent changes in the resource. The idea presented in this paper is considered the development of the new product on prototype setup, time and cost saving of new product development.

PRODUCT DEVELOPEMENT APPROACH

Due to a load of global competition and market globalization in the recent years, therecontinue to be powerful propulsion forces in the industry to compete effectively by decreasing time to market and price while convincing top quality product and service (Choi, 2004; Anjorin, 2013; Hongbo 2009). Small product existence cycles and regularly rising consumer demands will define today's markets. The important parts of conventional manufacturing have complications to start fundamentally inventive hardware products at top speed and required capability to achieve success (McDermott, & O'Connor, 2002; O'Connor & Rice, 2001). The advanced approach to physical product development, the continuous stage-gate procedure model, is over worked with detection of radical product inventive (Schuh, et al, 2015). Manufacturing industries should restructure their procedure to fulfill the necessity for a successful development of radical products (Meyer, 2012).In a conventional approach, physical prototyping plays a important role in new product development (NPD).In particular, it empowers concurrent, time-oriented methods and create participation in teams made of people from

various functions and backgrounds (Vandevelde, et al, 2001).

Making design-decisions further effectively fabricate the product development procedure (PDP) further effective and provides a competitive edge (Seth, et al, 2011). A growing international competition, in both developed and developing nations, is a powerful inducement for companies to look for ways of making their PDP further effective. Because of this, western industries are depending mainly on enhancing their design and development procedure to maintain their position in the market (Carulli, et al, 2013). Substantial production plans for fulfilling these challenges are the method of mass customization (Da Silveira, et al, 2001).

A prototype is a cause full draft version of a design or parts of a design that permits the designer to range over his thoughts and to be in contact it to stakeholders and customers for assessment of the design (Yang, 2004). Prototyping does appear in all period of the PDP, with a different resolution (Falcão &Soares, 2014). A prototype can be manufactured to test all things from the aesthetic request to the quality of a technical resolution and can be all things from paper drawings to a fully operating prototype of a car. The most crucial cause for the necessity of prototyping is that variation to the design made early in the procedure are much less costly than variation made later (Lim, et al, 2008; Park, et al, 2008). Prototyping for the evolution of industrial products has conventionally been physical prototyping. Physical prototypes are physical descriptions of the design that are made of materials and elements that are simple to handle, so the fabrication time of the prototype becomes less. The drawbacks of physical prototyping are its excessive costs, evolution time and the less flexibility once the prototype is fabricated.

The main type of modern production is through cellular manufacturing. The performance and efficiency of small and medium size group manufacturing enhance by it and takes it closer to the high productivity and less cost incorporated with mass production. In a flexible manufacturing system manufacturing cells may be applied separately or as modules. The main principals leading to the evolution of manufacturing cells are elements classification and categorize into families with alike geometric and processing (Roozenburg & Eekels, 1995). Design of successful flexible manufacturing systems is done through group technology.

Many techniques are used for recognizing part families, computer-assisted elements coding, adding visual inspection, and categorization and inspection of design and production flow data. Some of categorization systems have involved opitz, multiclass and Dclass. The categorization process results in a code number that uniquely recognize the part's quality. It can be used for succeeding manufacturing planning or assignment to manufacturing cells. The Production Flow Analysis (PFA) makes utilization of the information accommodated on route sheets to group work section with similar routings into part families. The advantages of a well-designed system for parts grouping, cell design, and parts/cell task have been identified.

The PFA method and the applications of Artificial Intelligence techniques have been created the manufacturing simpler. In this, once manufacturing cells have been formed, it is necessary to evaluate methods and algorithms to help the on-going decision making regarding production planning and parts task to existing cells (Ferrise, et al, 2013). It is required to establish a link to integrate the product design and manufacturing modules and directly assign new parts to the appropriate existing manufacturing cell based on previously coded knowledge and expert rules.

The current available researches are mainly in scholastic in nature and cannot be implemented in industries because of following reasons:

- The visibility of published researched work in the domain is rather limited.
- Published research work is used in stimulate imagination, instead of validating ideas.
- Development of prototype into manufacturing process is not fully apparent in the bearing industry.
- Literature work reviewed is mainly based on one or another system CAD/CAM design and development, not having mass sample development through the manufacturing process.
- The literature review also presents the major focus is on the direction setting approach and need in-depth work to implement setup successfully in the organization.
- Validation of the proposed methodology is missing from industry based case study approach.

CHALLENGES AND SOLUTION APPROACHES

Any new idea in the organization needs an open mindset and readiness for change. Altering regular way of doing things is a major obstacle to executing new solutions. However, this is known reservation and organization need to have a good changeover plan for smooth transformation from regular process. The conventional manufacturing approach needs to be alteredto serve the dynamic requirements of the customers.

Challenges

Major challenges faced are as below:

- Currently, manufacturing of new bearing samples is highly subjected to availability of resources freed up from the demand for regular production asked by customers.
- The constrained capacity of the manufacturing line regarding technical requirements.
- Available literature is not focused on industrial needs of shortening lead times. Prototype manufacturing to execute in a different environment and thinking of sample development by a different process.
- Manufacturing activities are more driven by a set of process steps. The cross-functional level experience motivated the team to generate for development prototype manufacturing setup in the industry with a different approach.
- Management commitment towards NPD activities and exploring future business potentials.

Solution Approach

The first step to a solution is the cross-functional experienced team of experts in different fields has to be developed for the new Protoshop project. The Project management team is being authorized for collecting required data and analyzes them with the support of experienced team members.

The fundamental approach is to achieve the desired outcome which is further explored in the successive text

Understanding Current Manufacturing Process

In the conventional bearing manufacturing process, production engineers perform manufacturing operation on setup which is already established in the company. In the present setup grinding and super-finishing is done the online

setup. It consists of Inner grinding line setup operations are Track grinding, Flange grinding, Bore grinding and Track super-finishing on four different machines and Outer grinding line setup operations are done on Track grinding, Track super-finishing on two different machines. In the present setup different grinding line consists of six machines. The complete grinding and super-finishing setup are different for different type of bearings, i.e., Ball Bearing, Taper Roller Bearings, Cylindrical roller bearing. Team also gathered information where engineers need to follow steps for troubleshooting a situation and different activities being done to achieve the desired outcome. Prototype grinding and super-finishing setup require different thinking of performing multiple operations on fewer machines and performing the operation in different sequences to achieve the desired outcome.

Converting Current Manufacturing Know-How in to the Prototype Manufacturing Setup

The experienced engineers work in a cross-functional team for the development of new products. Budgetary requirements from functions such as research and development, quality and responsibility assignment for entire project duration needs to be identified. Major problems to reduce were converting judgment, experience and old manufacturing process know-how into different prototype manufacturing setup. Output validation is another critical activity to be considered by the cross-functional team.

Generating References for Prototype Setup

The academic and research-oriented setup is of lower importance for producing prototype components. End to end Protoshop manufacturing setup references also needs to be established. Which also includes developing guidelines for prototype setup so that any new engineer should be able to manufacture the new product on prototype setup and develop anew product in minimum time.

Finalization of Prototype Manufacturing Setup

Core Cross-functional team needs to finalize on prototype machines requirements for grinding and super-finishing operations in small setup for the different type of bearings, i.e., Ball Bearing, Taper Roller Bearings, Cylindrical roller bearing prototype sample development. Total four machines requirement was identified for complete grinding and super-finishing of all types of bearings. The complete setup consists of universal external and internal grinder, flange grinder and universal super-finishing machine.

Development of Prototype Manufacturing Setup

Establishing the theoretical process for prototype and acquiring necessary resources through a channelized approach with involvement of management representative is an executive level task. The resources once obtained need to be established for the required level of output.

Along with this, the efficiency of the prototype shop is also studied with the current level of activities. The reliability aspects also need to be given consideration.

RESULTS AND IMPACTS

The data presented in this paper is collected from bearing manufacturing industry's Protoshop development process initiative which is establishedto perform end to end grinding and super-finishing of bearing races.

The prototype development of bearing needs to be supported by Time and Cost study along with the quality-focused approach.

Time study is being carried out on defined process set for setting up the baseline to compare the improvement with Prototype manufacturing process initiative. The time-study results are clear indication that the prototype manufacturing process is improving the productivity of new bearing sample development. The comparison of time required for prototype development yields results as shown in Figure-1. Protoshop manufacturing initiative has helped the organization achieve 60 % of time reduction. There is significant reduction observed in tooling quantity with the help of prototype manufacturing line (figure 2). The scope of activities contains all the activities from operational side required for new sample development of bearings.

The study results are clear indication that Prototype manufacturing process is cost-effective. As shown in figure 3, post-protoshop manufacturing initiative, the organization achieved 81% saving of manufacturing line production. It is evident that prototype sample development is having substantial productivity benefits to the organization and this initiative need to be continued in the organization to gain customer confidence and reduce the product development lead time.

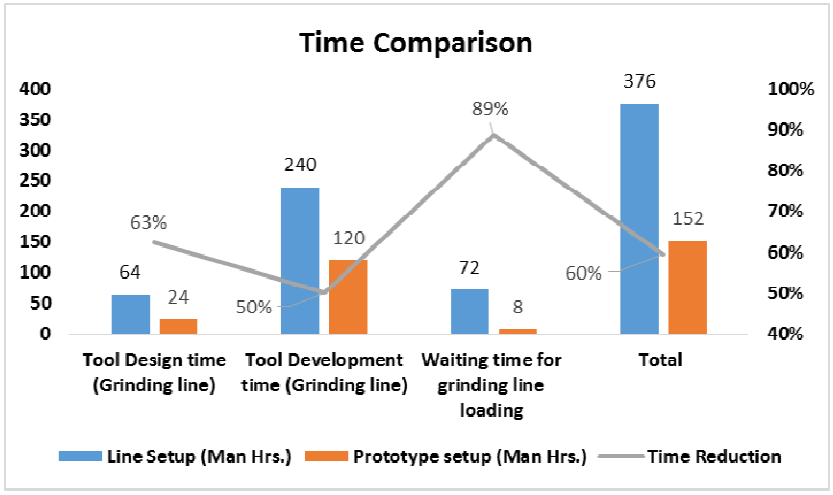

Figure 1: Comparative Time Study of Prototype Manufacturing (Line Setup Vs. Prototype Setup)

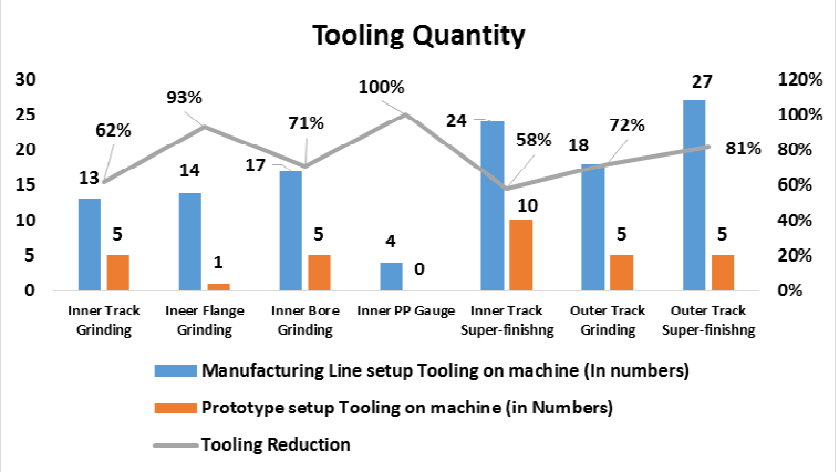

Figure 2: Comparative Tooling Quantity Required for Prototype Manufacturing (Line Setup Vs. Prototype Setup)

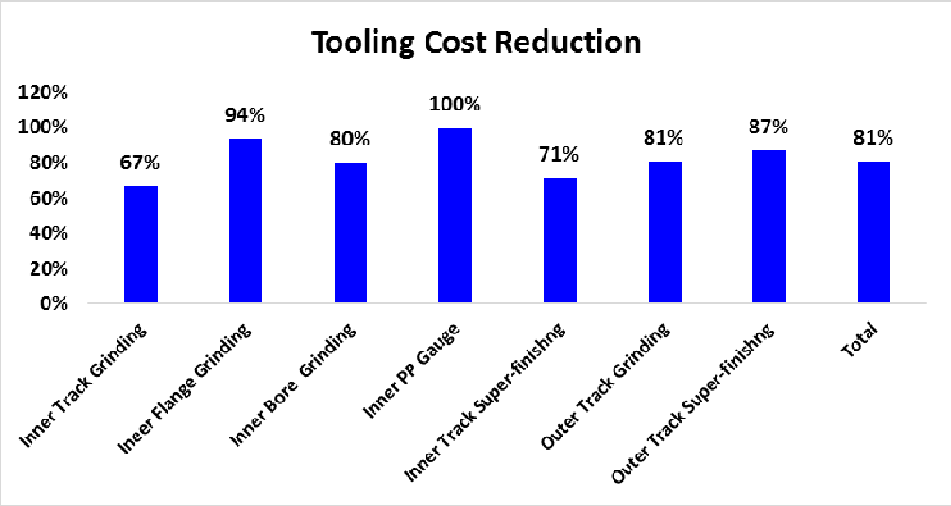

Figure 3: Comparative Cost Study of Prototype Manufacturing (Line Setup Vs. Prototype Setup)

Impact: Organization

The benefits derived from establishing protoshop environment running parallel to manufacturing setup yields multiple benefits to an organization. However from a current study following benefits can be listed out,

- Reduced tool design time.
- Reduced tooling development time.
- Reduced line settings.
- Reduced new product development time,
- Increase productivity as manufacturing lines are free from new product development setting time.

Improvements and Exceptions

Prototype manufacturing is required good technical know-how of machines and processes. The prototype manufacturing provides flexibility for developing ball and roller bearing on same machines, but a new generation of bearing development is not possible on same prototype setup. The prototype manufacturing only replaces initial sample production. However Production part approval process (PPAP) lots needs to be developed on manufacturing lines after receiving sample approvals from customers.

CONCLUSIONS

It is evident from the current study that prototype manufacturing initiative gives significant benefits on new product development time and cost saving fronts. Implementation of prototype manufacturing initiatives and new product sample development depends upon the organization top management support. It is resource intensive activity thus it needs facilitation of the organization resources. Detailed knowledge of manufacturing processes, knowledge of different designs of products, knowledge of machines, the interaction of product development processes and guidelines for prototype manufacturing are key factors for successful implementation of the protoshop approach. Efficient manufacturing process and product inputs to prototype manufacturing enable theorganization to achieve a better saving in time and cost of initial

sample submission. In addition to tangible benefits in terms of time and cost saving, resource efficiency improvement, this initiative also help to boost the confidence of manufacturing team, lower dependence on manufacturing lines, reduced teamwork pressure, and enhanced team motivation.

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APPENDIX-1.1

Table 1: Comparative Time Study of Prototype Manufacturing (Line Setup Vs. Prototype Setup)

Operations	Line Setup (Man Hrs.)	Prototype Setup (Man Hrs.)	Time Reduction
Tool Design time (Grinding line)	64	24	63%
Tool Development time (Grinding line)	240	120	50%
Waiting time for grinding line loading	72	8	89%
Total	**376**	**152**	**60%**

Table 2: Comparative Tooling Quantity Required for Prototype Manufacturing (Line Setup Vs. Prototype Setup)

Operation	Manufacturing Line Setup Tooling on Machine (in Numbers)	Prototype Setup Tooling on Machine (in Numbers)	Tooling Reduction
Inner Track Grinding	13	5	62%
Ineer Flange Grinding	14	1	93%
Inner Bore Grinding	17	5	71%
Inner PP Gauge	4	0	100%
Inner Track Super-finishng	24	10	58%
Outer Track Grinding	18	5	72%
Outer Track Super-finishng	27	5	81%
Total	**117**	**31**	**74%**

Table 3: Comparative Cost Study of Prototype Manufacturing (Line Setup Vs. Prototype Setup)

Operation	Manufacturing Line Setup Tooling on Machine (in Numbers) - Rs.	Cost of Tooling (Line Setup)	Prototype Setup Tooling on Machine (in Numbers)	Cost of Tooling (Prototype) - Rs.	Tooling Cost Reduction
Inner Track Grinding	13	30000	5	10000	67%
Ineer Flange Grinding	14	40000	1	2500	94%
Inner Bore Grinding	17	50000	5	10000	80%
Inner PP Gauge	4	10000	0	0	100%
Inner Track Super-finishng	24	70000	10	20000	71%
Outer Track Grinding	18	52000	5	10000	81%
Outer Track Super-finishng	27	78000	5	10000	87%
Total	**117**	**330000**	**31**	**62500**	**81%**